

Abstract

In general, women may begin participating in endurance type activities such as running, biking, and swimming to manage body weight. In order to obtain the desired results, dietary restriction is often partnered with endurance exercise to the point of potential metabolic consequences (low metabolic rate and higher body fatness). This study hypothesized that women who are more vested in their appearance and more dissatisfied with their body will have a lower metabolic rate and higher body fatness as a result of their exercise tendencies and potential restrictive diets. Chronic dieters may have a decreased resting metabolic rate, which may promote the storage of body fat for energy. We evaluated thirty-five tri-athletes (women ages 20-40) running at least 8-10 miles per week, biking at least 2 hours per week, and swimming at least 2 hours. The study protocol employed questionnaires for silhouette rating, EDE-Q, MBSRQ and the tendency to diet scale (TDS) to score the athletes on appearance orientation, appearance evaluation, body shape concern, dietary restriction, dieting tendencies, and silhouette ranking to indicate body dissatisfaction. Resting metabolic rate was determined by a single early morning measure using the ReeVue Indirect Calorimeter and body composition was assessed using the GE iDXA system. Statistical analysis used simple Spearman correlations to determine the potential relationship between each of the questionnaire outcomes with resting metabolic rates and body fatness. After data analysis, no significant correlations were found between percent fat with AO, AE, TDS, EDE-Qs, and Silhouettes or when comparing RMR with AE, Tendency to Diet scale, EDE-Qs, and Silhouette drawings. There was a significant relationships found between RMR and AO. Despite these results that didn't mimic all hypotheses it is important to continue with research on this same study with more participants and to further the research on

female athletes in order to educate women on their bodies and how to properly nourish them for sport and activity.

Body Image and Body Composition of Female Tri-athletes

A Senior Honors Thesis

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Introduction

Tri-athletes are hardworking performers who train to excel in cycling, running, and swimming. Because a tri-athlete can burn thousands of calories during a triathlon and during training, they need to consume adequate calories to support metabolic function. Anecdotal evidence supports that women tri-athletes often restrict caloric intake, which can have adverse effects on physiology including body composition and a lower resting metabolic rate.

This research was designed to determine the relationship between body composition, RMR and dieting attitudes and body image of female tri-athletes aged 20 to 40 years. The surveys combined as one digital tool were the Silhouette Rating difference between real and ideal, Eating Disorder Examination (EDE-Q) (restraint, eating, shape and weight subscales), Multi-dimensional Body- Self Relations Questionnaire (MBSRQ, appearance orientation and evaluation subscales), and the Tendency to Diet Scale (TDS) (5, 6, 13, 19, 31, 35) Athlete demographics, physical activity level and menstrual status were also queried in the questionnaire along with the Reason for Exercising questionnaire (31). Additionally, subjects had measurements of body composition taken using the iDXA. RMR was estimated using the ReeVue indirect calorimeter.

The tools used in the research will help the research team answer these questions:

- 1) Do the Appearance Orientation (AO) and Appearance Evaluation (AE) domains of the Multidimensional Body Self-Relations Questionnaire correlate with a decreased resting metabolic rate or body fatness?
- 2) Do the subscales of the Eating Disorder Examination (concern for Weight, Shape, Eating, and Restraint) correlate with a decreased resting metabolic rate or body fatness?

- 3) Does Tendency to Diet score correlate with a decreased resting metabolic rate or body fatness?
- 4) Do the differences between perceived and ideal Silhouette drawings, suggestive of the body satisfaction of an individual, correlate with a decreased resting metabolic rate or body fatness?
- 5) Does the inclusion of reason for exercise impact the relationship of body fatness and resting metabolic rate to these dieting attitudes and body image scores?

Literature Review

Female athletes are influenced by a variety of ideologies, which have an impact on how they view their bodies. Not only are they faced with media images and the pressure of social and cultural norms, but also they likely feel compelled to attain a specific body type for their sport. Girls today are encouraged to have a more fit body and to be strong and competitive, which adds to their pressure (2). Tri-athletes are specifically examined in a separate category because they are applying an immense amount of stress to their body through a very high level of endurance activity.

There are different levels of tri-athletes, which include Short Distance Olympic Distance, Half Ironman, and Ironman categories as outlined in Table 1.

Table 1. Categories of Tri-athletes by competition mileage

Category	Swim	Bike	Run
Short Distance	.24-.62	5-15.5	1-3
Olympic Distance	.93	24.86	6.21
Half Ironman	1.2	56	13.1
Ironman	2.4	112	26.2

Depending on category, female tri-athletes are expending many calories to train and participate in races, and may not always be consuming adequate calories to support the mileage.

Hoch and Lynch (2010) discuss the differences between men and women, and how media's pressure to be thin affects women more often than men (24). Other important differences are highlighted as well, such as anatomical size differences, and differences in male and female physiology. For example, women tend to be smaller than their male counterparts in general and have less muscle mass. Furthermore, women tend to have more body fat due to the influence of estrogen during the reproductive years. To demonstrate how these differences may come together to influence body image, current exercise research also shows that women are more likely than men to exercise for weight control, body tone, and attractiveness reasons (33). Women seek out recreational programs with the intent of losing weight, and recreational programming designed for women often includes weight-loss as a key goal (7). Another study to highlight the differences between men and women shows that body dissatisfaction occurs in both genders, but women rarely want to be heavier and are happier about being underweight (31). There is a need for more research on the exercising female to help women understand more about their bodies and how to nourish them for best function and weight management when exercising at a high endurance level or high intensity.

Considering why people exercise has also been shown to be correlated with body dissatisfaction (36). Women who exercise for health and fitness reasons tend to be more satisfied with their bodies, whereas women who exercise for weight control and/or body tone and attractiveness reasons are more often dissatisfied with their bodies. When higher body dissatisfaction drives an individual to extreme levels of exercise or mileage with minimal nutrition support to seek a more satisfying body, the athlete may ironically be setting herself up

for lower RMR and higher body fatness.

Body Image

Body image is historically shown to influence dieting behaviors and the way a woman fuels herself. A recent body image study conducted by Sears et al. evaluated the body image of female athletes with or without eating disorders (22). Sears found that body image was the strongest predictor of risky eating behaviors in female athletes in the population that was studied supporting the connection between body image and nutrition behaviors. Sears et al. also suggested that athletes fear of being honest on the usual eating disorder questionnaires will jeopardize their playing status or athletes may be in denial. They propose that body image tools may be less threatening thus garner more accurate information (22).

The tool chosen to measure body image is also an important research consideration. Sears used the well-established MBSRQ as the measure of body image. In the original MBSRQ studies, Cash and Green suggested that normal and underweight individuals are more oriented toward appearance compared with overweight individuals (5). Overweight subjects were more dissatisfied with their appearance, but no significance differences were seen in grooming behaviors.

There are very few studies to characterize body image in female tri-athletes. Cronan and Scott found that women were more likely to exercise for weight control and the majority of women objectify the body as a thing (7). Although Cronan et al focused more on subjective data (personal and narrative descriptions), it is further supported by the 2007 tri-athlete study by Hoch et al., which suggests that women tri-athletes are at risk for developing the female athlete triad: low energy availability (with or without eating disorders), amenorrhea, and osteoporosis (16, 25). The Eating Attitude Test (EAT-26) assessed disordered eating and eating habits of the 15

subjects in Hoch's study. A 3-day food record was collected and evaluated, and each subject completed a body image questionnaire. Both studies support subjects' eating habits and body image to be strongly connected, and to greatly affect their performance as athletes through their body composition.

Other studies on adult females in general have demonstrated similar issues with women and dieting practices, and the effects of food intake on RMR. One study on college-aged women illustrated that 83% of participants used diet for weight loss and thought that they would be heavier if they weren't dieting, and 80% reported doing physical activity to control weight (3). Many of the participants also reported eating less than they wanted and some skipped breakfast. From this study, the researchers suggested that more educational practices and research be done to encourage healthier weight management practices (3).

Other research in the general population has suggested that restrained eating can cause a decrease in RMR, but results have been mixed. Keim et al. used a 3-day diet intervention with restrained and unrestrained eaters and was not able to demonstrate that previous restrained eating altered the metabolic response to dietary restriction (21). Interestingly, REE went up when these subjects had the diet intervention, but REE went down for the unrestrained eaters, suggesting their baseline was even lower (21). A similar study did find a significant change in resting metabolic rate with restrained eaters when they looked at 12 restrained and 12 unrestrained eaters (28). This study suggested that the RMR went down with restricted eating behavior after a one-time intervention where there was a significant 123-calorie difference in RMR between restrained and unrestrained eaters when measured, but almost no difference in predicted (28). The collective data infers that dieting and restrictive eating can play a role in the metabolism of food, most like decreasing RMR for restrictive eaters, but more research should be done to

solidify this data in all groups of people.

A recent study examined a high drive for thinness (DT) as scored from the Eating Disorder Inventory-2, and related it to nutrition behavior and resting metabolic rate (14). A high DT promoted diet and exercise that is of the weight loss nature, which in turn could promote poor fueling or a low energy availability (14). There were also significant menstrual disturbances among the participants suggesting that a drive for thinness plays a large role in female athlete reproductive physiology.

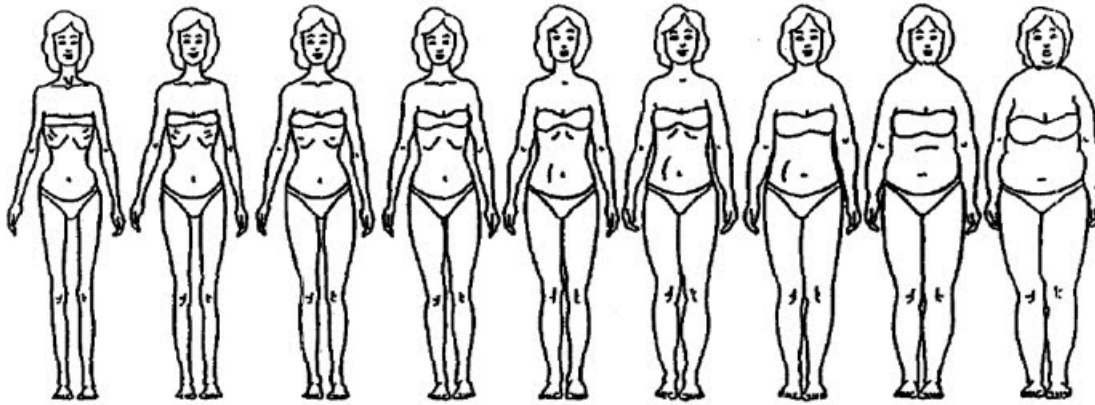
The MBSRQ is a self-administered questionnaire that has proven to be a robust tool to quantify body image. The full questionnaire is designed to evaluate appearance orientation and appearance evaluation, fitness evaluation and orientation, and health/illness orientation and evaluation characteristics. Each characteristic is determined using a continuous scale of numerical scores for each question, ranging from 1 (Definitely Disagree) to 5 (Definitely Agree). The sub scales are concerned with weight label, weight restraint, and body area satisfaction. Cash originally validated the MBSRQ in a 1986 study, which looked at 36 female undergraduate students to show that body image differed as a function of body weight (5). This original study found that women who completed the MBSRQ and “reported that they felt more unattractive and dissatisfied with their bodily appearance were more likely to believe that they were larger than their peers” (5). This research suggests the presence of a cycle similar to the hypotheses of this study. Women who score high in body dissatisfaction are more likely to think they are bigger and then diet or exercise to get to a body image that they think is better. Brown et al. demonstrated this well in a sample of 2051 males and females ages 15-87 achieving concordance values of 0.995 for Appearance Evaluation and 0.997 for Appearance Orientation (4). Using the MBSRQ is a standardized measure of body image for appearance orientation and appearance

evaluation in females and in female athletes (5, 22).

The MBSRQ incorporates the appearance orientation (AO) and the appearance evaluation (AE) subscales, which indicate different aspects of body image. The AO subscale is used to determine the level of importance one places on appearance by taking into account what practices or activities participants display in order to maintain or alter his/her appearance (4). A high AO score indicates that a person places high importance on their appearance while a low AO score indicates that a person does not consider their appearance to be an important reflection of themselves. The AE subscale indicates how the subject evaluates personal appearance, or how pleased or satisfied she is with her body, and what practices she adopts to alter or maintain body satisfaction or dissatisfaction (4). A higher AE score indicates a subject is pleased with body appearance and lower scores indicate more body dissatisfaction. The AO and AE subscales of the MBSRQ provide objective markers of orientation and evaluation of appearance.

Silhouette drawings have been widely used amongst researchers and clinicians as another method to evaluate body satisfaction and body image. Original research by Stunkard showed the silhouette drawings suitable for use with adolescents, but further research continued to be done, which Gardner illustrated in the figural scale review (12, 35). The tool includes simple illustrations to represent a spectrum of body types where each silhouette was originally associated with a particular Body Mass Index (BMI) (34).

The ease of administration makes this tool attractive to researchers. From the continuous scale of silhouettes illustrated in Figure 1, subjects are asked to choose their current body silhouette and ideal silhouettes (27).



Any deviation of the participant's ideal body silhouette from their perceived body silhouette indicates body dissatisfaction; as the perceived and ideal body silhouettes become more incongruent (higher number), body distortion increases, demonstrating a high degree of body dissatisfaction and body distortion (13). The perceived difference between one's perceived body and ideal body or silhouette differential can be a contributing motivation to practice an imbalanced restrictive dieting or over-exercising pattern (20).

The silhouette questionnaire has been validated a number of times. Peterson et al. found that the reliability scores from current and ideal body images were acceptable and significant when looking at 172 high school students who completed pre and post tests (27). Test-retest measures for all BMI-SMT scales showed results that were highly significant with Pearson r coefficients at $P < 0.0001$ and correlations for Current Body Image were $r = 0.85$ for females, and $r = 0.79$ for males and Desired or Ideal Body Image illustrated values of $r = 0.82$ for females and $r = 0.83$ for males (27). Peterson et al. also identified females to have a significant divergence from perceived body image and desired body image. The original Stunkard article illustrated a test retest reliability of .87 for current and .83 for ideal size. Gardner's figural scale also showed high reliability with the most recent at .86 for current size and .72 for ideal size (12). The Silhouette differences between perceived and ideal body image is an easy indicator of body

satisfaction.

The EDE-Q has also proven to be a reliable indicator of restrictive behaviors and eating disorder pathology. The original work by Cooper and Fairburn demonstrated acceptable internal reliability with fair Cronbach's alpha values for the tool subscales as outlined in Table 2 (6).

Table 2 Subscales of the EDE-Q and internal reliability measures.

EDE-Q Subscale	Cronbach's alpha for internal reliability
Restraint concern	0.75
Eating concern	0.78
Weight concern	0.67
Shape concern	0.79

Further work by Fairburn and Beglin demonstrated EDE-Q to be valid regardless of delivery method, such as interviewing or self-report questionnaire, and they attributed this to the unambiguous definitions provided (9). The EDE-Q has a variety of responses that include an estimation of the number of days a participant displayed a dieting behavior in the previous 28 days, and numerical Likert-style responses ranging from 0 (Not at all) to 6 (Markedly). A higher EDE-subscale score indicates that a subject places a greater focus or concern on shape (EDE-S), weight (EDE-W), eating (EDE-E), or restraint (EDE-R) and is at a higher risk for practicing restrictive eating behaviors. The EDE objectifies these four perspectives of body image and attitudes.

Other studies have used the EDE-Q to study body image. A study conducted using women aged 18-42 in Australia showed mean normative scores to be 1.30 (1.40), 0.76 (1.06), 1.79 (1.51), 2.23 (1.65), and 1.52 (1.25) respectively for the following EDE-Q subscales: restraint, eating

concern, weight concern, shape concern, and global score (18). Additionally, in this same study, researchers found normative data for specific age ranges and also observed that scores on the eating concern, weight concern, shape concern scales, and the global score, tended to decrease with age.

The Tendency to Diet Scale (TD) is a 15-item questionnaire that includes behavior and attitude questions that help objectify dieting behaviors. It was created and validated in the RENO Heart Study to indicate one's dieting behaviors and attitudes about the need to diet. The RENO study was able to show that TD is a reliable tool to use in a clinical setting. This scale has not been validated in athletes specifically, but correlations have been observed with the scale and body weight (19). Overweight individuals tend to score higher on the TD scales than normal weight individuals, and women have higher scores than men. Although, the sample studied largely consisted of educated and Caucasian subjects, one study found no differences among black and white women. It has thus been suggested that the scale could be utilized in diverse populations (19).

Resting Metabolic Rate

Resting metabolic rate is defined as the energy expended in a resting state following an overnight fast and is the energy needed to maintain body processes. Many factors have been found to influence RMR including age, gender, ethnicity, and body composition (29). There is a strong, direct relationship between fat free mass (FFM) and RMR because FFM (which includes muscles, bone, and organ masses) is more metabolically active, therefore requiring more energy to maintain (10, 23). It has also been reported that exercise and/or physical activity can change a person's RMR. With an adequate amount of progressive exercise someone can increase their lean muscle tissue, which may increase RMR or other metabolic effects of exercise, and physical

activity can have an impact on metabolism (32).

The effect of exercise on metabolism has been researched on both the short term and the long term. Research supports that 30-45 minutes of exercise can increase RMR by 10-15% for no longer than 72 hours. Most studies suggest that excess post-exercise O₂ consumption (EPOC), term for increased metabolism after a single exercise bout, stops after just two hours, but some have shown an increase for up to 48 hours. Research on long-term exercise effects on RMR is less clear. This type of research is more complicated because of the many factors involved, including type of exercise, how long after exercise the subjects are tested, if they have gained fat-free mass, but lost total weight over course of study, and if they are restricting diet. Some studies showed an increase in RMR 72 hours after the last exercise bout. Another study, however, suggested that subjects who walked and did resistance training actually decreased RMR, but they were not looking at energy restriction (32).

The ReeVue indirect calorimeter measures oxygen consumption (VO₂) and estimates Resting Metabolic Rate (RMR) based on the measured VO₂ using an assumed respiratory quotient (RQ=0.83). This machine is a common clinical tool to estimate resting metabolic rate. The reliability and validity are published at $\pm 10\%$ of those measured with a DeltaTrac system (26). This device is an FDA-approved device standardized for clinical estimation of the metabolic rate. The data presented in one study showed that energy expenditure measurements are very similar for the DeltaTrac system and the ReeVue, and that metabolic rate can indeed be calculated without carbon dioxide measurements (26). Other similar systems are also validated. The MedGem/ BodyGem indirect calorimeter, which is a common RMR device used in the clinic was shown to be reliable and valid against previously validated devices by researching published articles (30). The ReeVue indirect calorimeter is a practical and reliable indicator of

RMR in the laboratory.

Body Fatness

Body composition estimation can be achieved using various methods. The iDXA is an x-ray bone densitometer system that sends different beams of energy through the table surface and a person's body to a sensor that scans over the subject's body. Understanding how the energy changes as it passes through different tissues is how the iDXA determines bone density, body fat, etc. The energy is an X-ray beam that consists of photon particles, which lose energy through physical reactions when they pass through tissue. The decrease in energy depends on the type of tissue that the beam diffused (37). The iDXA used for this study is the most updated version of the iDXA machine and has been shown to be an excellent test for determining body composition (23). The iDXA has a precision error of $< .5\%$ for lean mass and bone mineral content, and less than 0.8% for total body fat (23). Another study examined the precision of the DXA and reported that with two consecutive total body scans, precision was excellent for all measurements, particularly for total body bone mineral content and lean tissue mass (root mean square 0.015 and 0.244 kg; coefficients of variation (CV) 0.6 and 0.5% , respectively) (15). The iDXA has been compared to other similar systems such as DPXL and Prodigy where it was observed that there was a high agreement among the systems, but that cross calibration equations should be used to avoid any error when changing machines(17). Additionally, it has been suggested that air displacement plethysmography, bioelectrical impedance analysis (BIA), and DXA are sensitive enough to detect changes with weight loss and that the first two are highly comparable to DXA (11). Body composition (BC) assessments by DXA are readily available, less expensive and less invasive compared with other diagnostic imaging techniques, such as MRI and CT and they are also safe. Bone mineral density (BMD) and soft-tissue composition can be measured not only as

the whole body but also in specific regions of the body, which makes the DXA an important tool not only for assessing and managing osteoporosis, but also for examining soft tissue composition changes in healthy and diseased populations (1).

Calorie Restriction

A benchmark study by Deutz et al. serves as the impetus for this current study of tri-athlete women. Deutz et al. examined the dietary restriction, metabolic rate and body fatness of (tell us about the number and type of female athletes) (8). Deutz found that energy deficits in athletes were associated with a higher body fat percentage, whereas energy surpluses, or consuming too many calories for one's expenditure, were ironically associated with lower body fat percentage (8). This was thought to be true because the human body adapts to restrictive food intake by functioning with a lower resting energy expenditure than it would with adequate intake.

A more recent study also addressed resting metabolic rate alongside Drive for Thinness. This is supported by a recent study showing that there were significantly more cases of energy deficiency observed in women with a high drive for thinness (DT) than women with normal drives (14). The drive for thinness was associated with menstrual disturbances as well (13). A drive for thinness can lead to calorie restriction, which can be the starting point for the decrease in RMR that in turn can affect how the body is functioning and start to shut down certain systems such as the reproductive organs. Additionally, energy may decrease and performance will suffer, which can be especially challenging for the tri-athlete population.

Methodology

Subjects

Study participants were female tri-athletes from twenty to forty years old. All participants had to be running at least eight to ten miles per week, biking at least two hours per week, and

swimming at least two hours per week by self-report during the period that they were tested. The study sought thirty-five subjects. The Institutional Review Board at The Ohio State University approved all protocol methods prior to subject participation.

Questionnaires

After informed consent, participants were asked to complete an on-line compendium of body image questionnaires as the first station when they arrived at the lab. The questionnaire was housed on a secure server using the Qualtrics Research Suite (Qualtrics) through the College of Education and Human Ecology. Athlete demographics, physical activity level and menstrual status were queried along with the multiple body image and eating attitudes. The body image of each subject was defined by appearance orientation and appearance evaluation subscales of the Multidimensional Body-Self Relations Questionnaire (MBSRQ). To further assess the participants' body dissatisfaction, subjects were asked to identify perceived and desired silhouettes (35). The Eating Disorder Examination Questionnaire (EDE-Q) was used to define the tendency of the subject to practice restrictive eating and body weight or shape concern. The Tendency to Diet scale was used to objectify the dieting behaviors. Finally, the larger questionnaire included the Reason for Exercise questionnaire (5, 6, 13, 19, 31, 35). Questionnaire responses were exported from the survey tool database; imported into Excel, and subscales were calculated in Excel for merging with the other data for statistical analysis.

Laboratory measures of Body Composition and Resting Metabolic Rate

The GE Lunar iDXA system was used to estimate percent body fat and fat free mass (FFM) of all participants. All subjects were instructed to wear appropriate clothing (no metal) and were screened for a negative urine pregnancy test prior to the iDXA scan. A single technician operated the scanner and all measures were taken per machine protocol. Data from the

iDXA including weight, fat distribution and percent, and bone density was exported from the database and collated into a larger Excel data file for statistical evaluation.

After lying supine for about 20 minutes for the iDXA testing, the resting metabolic rate was estimated using the ReeVue indirect calorimeter technology. The lab visits were early morning visits to attempt to capture the most accurate resting metabolic rate. Subjects were instructed to refrain from eating, drinking, or exercising the morning of the lab visit. After the breathing phase of the test, lasting around 10 minutes, subject data was entered into the ReeVue machine to translate the oxygen uptake of the athlete to the estimated RMR from the Harris-Benedict equation. The printed values from the RMR machine were then manually entered into Excel for collation with the other study variables.

The collated Excel data file was then imported into SAS (version 9.2, Cary NC) for statistical analysis. The correlations between the questionnaire data and the estimates of RMR and body fatness were evaluated using Proc Corr. The influence of reason for exercise was evaluated running the same models in the General Linear Model command to control for reason for exercise. Statistical significance of the correlations and linear models was set at the $p < 0.05$ apriori.

Results

All subjects who participated in the study completed each part and were used in analysis. Table 1 illustrates the descriptive statistics of the total sample consisting of 22 female tri-athletes.

Table 1. Descriptive statistics for sample of female tri-athletes analyzed in this study.

Variables for n=22	Mean	SD	Range
Age	28.1	5.8	20.2-37.1
Height (in)	64.77	2.67	60.0-70.0
Weight (lb)	133.98	11.62	106.22-151.53

Years of Experience	Mean	SD	Range
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Run	7.10	4.98	.3-22
Bike	4.31	2.70	.3-11
Swim	5.24	5.95	.3-22

Table 2. Years of Tri-athlete Experience.

The descriptive data indicating the experience of the female tri-athlete subjects shows a wide range of familiarity with the sport. There was a range of 3.6 months to 22 years.

Body Composition and Resting Metabolic Rate

The average resting metabolic rate for the subjects was 1447 ± 173.0 kcal/day with a range from 1051 to 1714 kcal/day. Percent body fat averaged at $24.9\% \pm 6.0$ and the range was 15.2-37.4%.

Questionnaires

Table 3. Correlations between body image indicators and percent body fat and resting metabolic rate.

Question/Hypotheses	Outcome Variable	Pfat	RMR
Q1. Do the Appearance Orientation (AO) and Appearance Evaluation (AE) domains of the Multidimensional Body Self-Relations Questionnaire correlate with a decreased resting metabolic rate or body fatness?	AO	$r=-0.02999$ $p=0.8946$	$r=-0.53114$ $p=0.0110$
	AE	$r=-0.324$ $p=0.142$	$r=0.022$ $p=0.924$
Q2. Do the subscales of the Eating Disorder Examination (concern for Weight, Shape, Eating, and Restraint) correlate with a	EDE-EC	$r=0.17861$ $p=0.4265$	$r=-0.35926$ $p=0.1006$
	EDE-ER	$r=-0.10992$ $p=0.6263$	$r=-0.19166$ $p=0.3928$
	EDE-SC	$r=0.31731$ $p=0.1502$	$r=-0.07104$ $p=0.7534$

decreased resting metabolic rate or body fatness?	EDE-WC	r=0.26931 p=0.2255	r=-0.19366 p=0.3878
Q3. Does Tendency to Diet score correlate with a decreased resting metabolic rate or body fatness?	TDS	r=0.30556 p=0.1667	r=-0.19036 p=0.3961
Q4. Do the differences between perceived and ideal Silhouette drawings, suggestive of the body satisfaction of an individual, correlate with a decreased resting metabolic rate or body fatness?	SilDif	r=-0.08327 p=0.7126	r=-0.01637 p=0.9424

The subjects completed all questionnaires online when they arrived at the lab where they were able to answer questions regarding Appearance Orientation (AO), Appearance Evaluation (AE), Eating Disorders Examination-Eating Concern, Eating Restraint, Shape Concern, Weight Concern (EDE-EC, EDE-ER, EDE-SC, EDE-WC), Tendency to Diet Scale (TDS), and Silhouette Difference Scale. Each subject's scores were then correlated with percent body fat and RMR. After data analysis, no significant differences were found when correlating percent fat with AO, AE, EDE-Q subscales, Tendency to Diet scale, and Silhouette drawings. There were also no significant difference found when correlating RMR with AE, EDE-Q subscales, Tendency to Diet scale, and Silhouette drawings; therefore, measures on each questionnaire did not significantly correlate with decreased body fat or decreased RMR. There was, however, a significant difference found between RMR and AO, indicating that there was a significant correlation between the AO score and decreased RMR.

One other interest in this study was to see if the body fat and RMR results were influenced by reasons for exercise. We collated ‘Why weight concern, attractiveness, and tone’ into a continuous variable to represent exercise for aesthetic reasons. We then modeled RMR and percent body fat with each body image variable controlled for reason for exercise. All models were insignificant.

Answering the Research Questions

- 1) *Do the Appearance Orientation (AO) and Appearance Evaluation (AE) domains of the Multidimensional Body Self-Relations Questionnaire correlate with a decreased resting metabolic rate or body fatness?*

There was not a significant correlation between the MBSRQ subscale AO and percent fat but there was a significant correlation between AO and RMR with $p=0.0110$. AO scores are correlated with a decreased RMR. There was no significance found between AE and percent fat or RMR. It is also important to note that one question utilized in the AE subscale was unintentionally left out of the questionnaire; therefore, if significance had been found it would not be valid.

- 2) *Do the subscales of the Eating Disorder Examination (concern for Weight, Shape, Eating, and Restraint) correlate with a decreased resting metabolic rate or body fatness?*

There were no significant differences found between any of the Eating Disorder Examination subscales and Pfat or RMR. EDE-Q subscales did not appear to be correlated with a decreased resting metabolic rate or decreased percent body fat in this particular study.

- 3) *Does Tendency to Diet score correlate with a decreased resting metabolic rate or body fatness?*

There was not a significant difference found when comparing the Tendency to Diet Scale with RMR or Pfat. The TDS scores did not appear to be correlated with a decreased resting metabolic rate or decreased percent body fat in this particular study.

- 4) *Do the differences between perceived and ideal Silhouette drawings, suggestive of the body satisfaction of an individual, correlate with a decreased resting metabolic rate or body fatness?*

Differences between perceived and ideal Silhouette drawings did not correlate with a decreased resting metabolic rate or decreased percent body fat in this study. There was not a significant difference found when comparing the Silhouette Difference questionnaire with RMR or Pfat.

- 5) *Does the inclusion of reason for exercise impact the relationship of body fatness and resting metabolic rate to these dieting attitudes and body image scores?*

There was not a significant impact seen when looking to see if the inclusion of reason for exercise impacted the relationship of body fatness and resting metabolic rate to dieting and body image scores.

Discussion and Conclusion

This study was unable to support a firm relationship between body image and eating attitudes as correlated with RMR or body fatness. However, it is imperative to be aware of the small sample size. There were only 22 subjects tested for this study, where other studies showing significance using the EDE-Q and similar eating restraint questionnaires used more subjects including one potentially overpowered study with 5,255 subjects (18). One particular study that did not find a significant correlation with dietary restriction and a decreased RMR also had few subjects at 30. There was no conclusive evidence found to suggest that the other questionnaire

scores correlated with resting metabolic rate or body fatness either, excluding the AE domain of MBSRQ. A study on female athletes that showed statistically significant results when comparing the MBSRQ with risky eating used 423 subjects (22). Although these studies and others do not consist of the same population, it is possible that a larger sample size might be necessary to overcome the variance of RMR and body fatness measures.

Interestingly, the Appearance Orientation (AO) domain of the Multidimensional Body Self-Relations Questionnaire was found to significantly correlate with a decreased resting metabolic rate, but not body fatness. There were no correlations seen with the Appearance Evaluation (AE) domain, but this domain was not presented accurately because a question was accidentally left out of the subscale. AO's correlation with a decreased RMR may suggest that subjects who place more importance on their appearance tend to have a lower resting metabolic rate. This could be due to these subjects having a greater tendency to restrict their food intake, but there was no significance found when analyzing the Tendency to Diet Scale with RMR and percent fat. To better understand this relationship there needs to be further research conducted in this area with more subjects along with more intense statistical modeling.

Another limitation to this study, besides a small sample size, was that there was a wide range of ages included, but not enough people to allow an analysis of age ranges. There could be possible differences in metabolism and body composition due to age, which in further research should be accounted for. Additionally, the subjects had a wide range of tri-athlete experience, which should also be accounted for in a future study with more subjects. There were tri-athletes in this study that had experience in many triathlons and others who were just beginning. There could have been a set amount of experience needed to be included in the study. This study could have set more stringent inclusion criteria but chose to include recreational level tri-athletes. This

resulted in a larger than expected variability in triathlon mileage and experience. A higher inclusion threshold could have ruled out differences between a person with 3 months of experience and a person with 22 years of experience. Again, all of this information can be used for future research with this particular study.

Although the results did not support the research hypotheses, plenty of things were learned through the process of carrying out this study. It was realized that the timing for recruiting subjects should be done during peak tri-athlete training versus the late fall and winter when tri-athletes may not be training as much. Another aspect to consider, again, is age. It was discovered that many tri-athletes are over 30 and even over 40, which may be due to the price of races and equipment used in triathlon training and competition, warranting more income. Furthermore, the general method for conducting research with an athlete population was learned and more knowledge was gained on specific research processes including obtaining the RMR for the subjects, the use of the iDXA machine, and also hydration testing. In the end, a study was completed, but there is definitely more work to be done in the future. This study itself can be continued with more subjects and other research can begin using the suggestions from this report. It is important that further research be done to help women further understand their bodies and so that athletes can learn to nourish their bodies in a healthy manner for their activity level.

References

1. Andreoli A, Scalzo G, Masala S, Tarantino U, Guglielmi G. Body Composition Assessment By Dual-Energy X-ray Absorptiometry (DXA). *Radiol Med*. 2009; 114:286,286–300.
2. Benjamin HJ. The female adolescent athlete: specific concerns. *Pediatr Ann*. 2007; 36(11):719-26.
3. Brenda M Malinauskas, Thomas D Raedeke, Victor G Aeby, Jean L Smith, Matthew B Dallas. Dieting practices, weight perceptions, and body composition: A comparison of normal weight, overweight, and obese college females. *Nutrition Journal*. 2006; 5(1).
4. Brown TA, Cash TF, Mikulka PJ. Attitudinal Body-Image Assessment: Factor Analysis of the Body-Self Relations Questionnaire. *J Pers Assess*. 1990; 55(1):135.
5. Cash TF, Green GK. Body weight and body image among college women: perception, cognition, and affect. *J Pers Assess*. 1986; 50(2):290-301.
6. Cooper Z, Cooper PJ, Fairburn CG. The validity of the eating disorder examination and its subscales. *The British journal of psychiatry : the journal of mental science*. 1989; 154:807-12.
7. Cronan MK, D Scott. Triathlon and women's narratives of bodies and sport. *Leisure Sciences*. 2008; 30(1): p. 17-34.
8. Deutz RC, Benardot D, Martin DE, Cody MM. Relationship between energy deficits and body composition in elite female gymnasts and runners. *Med Sci Sports Exerc*. 2000; 32(3):659-68.

9. Fairburn CG, Beglin SJ. Assessment of eating disorders: interview or self-report questionnaire? *Int J Eat Disord*. 1994; 16(4):363-70.
10. Ferraro R, Ravussin E. Fat mass in predicting resting metabolic rate. *Am J Clin Nutr*. 1992; 56(2):460-1.
11. Frisard MI, Greenway FL, Delany JP. Comparison of Methods to Assess Body
Composition Changes During a Period of Weight Loss.
12. Gardner RM, Brown DL. Comparison of video distortion and figural drawing scale for measuring and predicting body image dissatisfaction and distortion. *Personality and Individual Differences*. 2010; 49(7):794-8.
13. Garner DM. The 1997 Body Image Survey results. *Psychology Today*. 1997; 30(1):30.
14. Gibbs JC, Williams NI, Scheid JL, Toombs RJ, De Souza MJ. The association of a high drive for thinness with energy deficiency and severe menstrual disturbances: confirmation in a large population of exercising women. *Int J Sport Nutr Exerc Metab*. 2011; 21(4):280-90.
15. Hind K, Oldroyd B, Truscott J. In Vivo Precision of the GE Lunar iDXA Densitometer for the Measurement of Total Body Composition and Fat Distribution in Adults. *European Journal of Clinical Nutrition*. 2011; 65:140,140-142.
16. Hoch AZ, Stavrakos JE, Schimke JE. Prevalence of Female Athlete Triad Characteristics in a Club Triathlon Team. *Arch Phys Med Rehabil*. 2007; 88(5):681-2.

17. Hull H, He Q, Thornton J, Javed F, Wang J, Pierson RN. iDXA, Prodigy, and DPXL Dual-Energy X-ray Absorptiometry Whole-Body Scans: A Cross-Calibration Study. *J Clin Densitom.* 2009; 12(1):95,95-102.
18. J.M. Monda, P.J. Hayb, B. Rodgersc, C. Owend. Eating Disorder Examination Questionnaire (EDE-Q): Norms for young adult women. *Behaviour Research and Therapy.* 2006; 44:53,53-62.
19. Kayman S, Brunner RL. Dieting Behaviors. *Obesity Assesment Tools, Methods, Interpretations.* 1997:352,352-362.
20. Keeton WP, Cash TF, Brown TA. Body image or body images?: Comparative, multidimensional assessment among college students. *J Pers Assess.* 1990; 54(1-2):1-2.
21. Keim NL, Horn WF. Restrained eating behavior and the metabolic response to dietary energy restriction in women. *Obes Res.* 2004; 12(1):141-9.
22. Leigh A. Sears P, Kathryn R. Tracy B, Nicole M. McBrier, PhD, ATC. Self-esteem, Body Image, Internalization, and Disordered Eating Among Female Athletes. *Athletic Training and Sports Health Care.* 2012; 4:29-37.
23. Lombardi RM. Bone Density as a Source of Error Measuring Body Composition with the Bod Pod and IDXA in Female Runners; 2011. 20 p.
24. Lynch S.L., Hoch A.Z. The female runner: Gender specifics. *Clin.Sports Med.Clinics in Sports Medicine.* 2010; 29(3):477-98.

25. Nattiv A, Loucks AB, Manore MM, Sanborn CF, Sundgot-Borgen J, Warren MP, American College of Sports Medicine. American College of Sports Medicine position stand. The female athlete triad. *Med Sci Sports Exerc.* 2007; 39(10):1867-82.
26. Orr JPD. Evaluation of A Novel Resting Metabolic Rate Measurement.
27. Peterson M, Ellenberg D, Crossan S. Body-image perceptions: reliability of a BMI-based Silhouette Matching Test. *Am J Health Behav.* 2003; 27(4).
28. Platte P, Wurmser H, Wade SE, Mercheril A, Pirke KM. Resting metabolic rate and diet-induced thermogenesis in restrained and unrestrained eaters. *Int J Eat Disord.* 1996; 20(1):33-41.
29. Ravussin E, Lillioja S, Anderson TE, Christin L, Bogardus C. Determinants of 24-hour energy expenditure in man. Methods and results using a respiratory chamber. *J.Clin.Invest.Journal of Clinical Investigation.* 1986; 78(6):1568-78.
30. Scott O. McDoniel ME. A Systematic Review on the accuracy and reliability of the MedGem®/ BodyGem® Indirect Calorimeter for Assessing Resting Metabolic Rate in Adults & Children. . 2007.
31. Silberstein LR, Striegel-Moore RH, Timko C, Rodin J. Behavioral and Psychological Implications of Body Dissatisfaction: Do Men and Women Differ? *Sex Roles.* 1988; 19(3/4).
32. Speakman JR, Selman C. Physical Activity and Resting Metabolic Rate. *Proceedings of the Nutrition Society.* 2003; 62:621,621–634.

33. Strelan P, SJ Mehaffey, M Tiggemann. Self-objectification and esteem in young women: The mediating role of reasons for exercise. *Sex Roles*. 2003; 48(1-2): p. 89-95.
34. Stunkard A. Old and new scales for the assessment of body image. *Percept Mot Skills*. 2000; 90(3).
35. Stunkard A, Sørensen T, Schulsinger F. Use of the Danish Adoption Register for the Study of Obesity and Thinness. *Association for Research in Nervous and Mental Disease*. 1983; 60:115,115-20.
36. Tiggemann M. Dietary restraint and self-esteem as predictors of weight gain over an 8-year time period. *Eating Behav*. 2004; 5(3): p. 251-9.
37. Toombs RJ, Ducher G, Shepherd JA, De Souza MJ. The impact of recent technological advances on the trueness and precision of DXA to assess body composition. *Obesity (Silver Spring, Md.)*. 2012; 20(1):30-9.